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Bridge Maintenance Automation

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Abstract

The investment maintenance of valuable buildings is nowadays performed continuously and by means of automated technologies and softwarized construction business systems organizations. For the purpose of the sustainability of traffic and buildings, the automation of technologies requires a matching automation of works- performing systems logistics within business operations as a whole. However, besides the information flow softwarizing, there are as well technological and organizational novelties aimed at the rationalization of the activities. Namely, the technological novelties are new machines-robots-and the organizational ones are the new formulae-the equations of procedures. Thus the vector methods provide for the fulfillment of investment supported by the scientific procedures that are in turn to contribute to the upgrading of indices to show the economic quality of not only a particular company but of state institutions as well. In other words, the aforementioned automation processes provide the possibilities for further scientific research and the development of society.

Keywords: investment, technology, organization, management, robot, software, vector norm, vector organization

1. Investment Maintenance of Bridges – introduction

An investment is an important factor both in constructing new buildings and in maintaining the already existing ones. An investment is observed as either direct placement of funds or as a continuous maintenance activity aimed at bringing a building back to function. Maintenance, i.e. increasing the longevity of buildings, as well as of all functional needs in the life of a man, is very important because of the rational activities of the human society that is in turn achieved by means of iterating investment system consisting of four phases, from conception to maintenance. (Fig. 1).

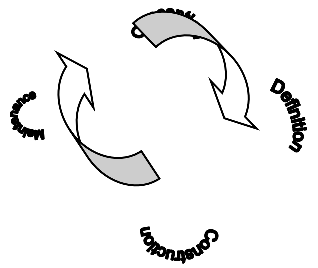


Fig 1. Iteration cycle with the investment phases cycle

It is especially so when the traffic buildings-bridges are concerned as the most important buildings connecting land stretches, or, precisely, road portions. The value of these buildings is always measured in millions of any currency so any society has to be extremely rational when the maintenance of bridges is implied. In these activities, besides political decisions, science has to take part as well as the main force to develop productive powers, i.e. to enhance the development of a society and a state.

In layman‘s terms, maintenance and reconstruction are said to be more expensive than the construction of a new building.

However, a continuous replacement of rapidly-dilapidated construction elements saves the main constructive elements from dilapidation thus decreasing the costs and providing for a longer time of use of a building and for the return of investments. (Fig. 2).

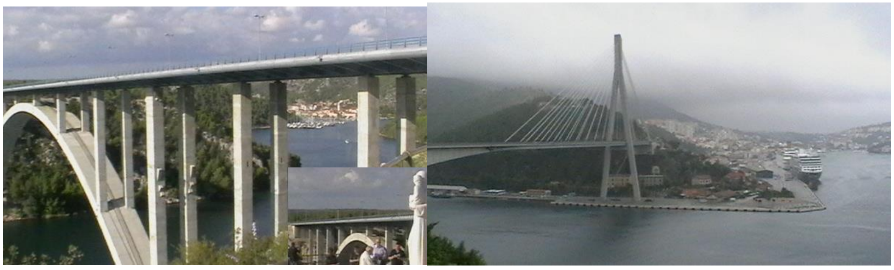


Fig. 2. Bridges in the Republic of Croatia

2. New Bridge Maintenance Technologies

Each construction activity is production. Production is a function of technology and organization (Eq. 1).

$$Production = f(T, O) \tag{1}$$

Each improvement in the organizational or the investment cycle is an important component of the profitability of an investment. Each one of the investment phases can contribute to the rationalization process and there is a special stress on the in situ dimension, i.e. a site or a building is inspected at the scene and this is what gives a spur to the new technologies and organizational elements. The maintenance of bridges in the Republic of Croatia is performed by the state-of-the-art technology, namely the modern hydrodemolition technology which, applied through Conjet robots and high-pressure pumps (Fig. 3), accelerates the investment cycle.

Fig. 3. Hydrodemolition of bridge plates by Conjet robots

3. New Bridge Maintenance Organizations

As organizations lag behind technology (Fig. 4), the tendency is to upgrade organizations so that they develop arm-to-arm with technology, i.e. arm-to-arm with the machinery.

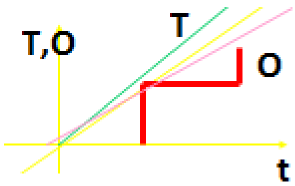


Fig. 4.The relation of production functions

The only way of achieving the aforeomentioned task is upgrading organizations to the level of technology by means of applied mathematics [1], i.e. turning static organizations into dynamic ones (Fig. 5).

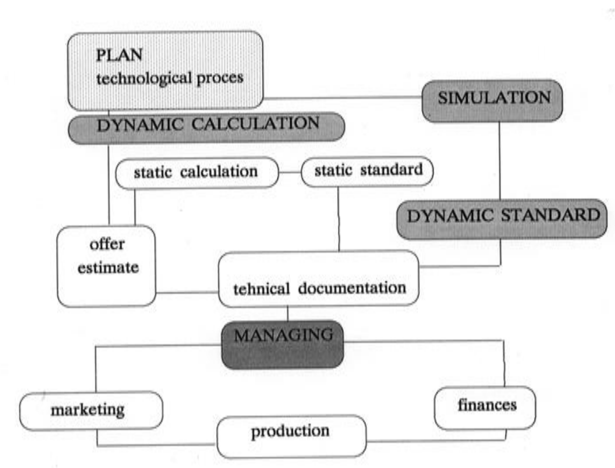


Fig 5 . Dynamic management of a programmed construction organization

A static norm is turned into a dynamic one by means of discovering new vector norms for the implied Conjet robots (Fig. 6) and other technologies as well. It thus turns the deterministic tabular shape of the static norms into the dynamic functional equations shown in the vector space [2].

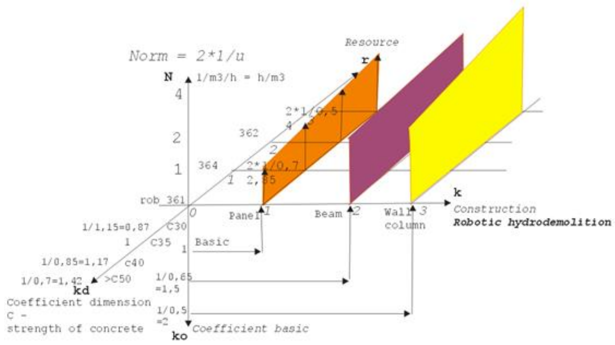
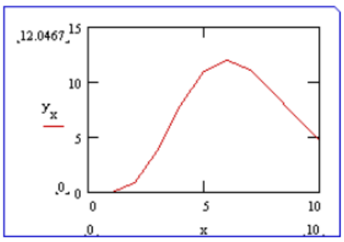


Fig 6. Vector norm of robotic hydrodemolition

The study of hydrodemolition works lead to the description of works by the Erlang distribution equations (Fig. 7) and equations (2) [3].



$$E(y_x) = \frac{k+1}{\lambda}; y_x = \lambda \frac{(\lambda x)^k}{k!} e^{-\lambda x} \quad (2)$$

Fig. 7 the Erlang distribution of the work of Conjet robot

The equation of the vector norm (3) for Conjet robots was derived from the analysis of the hand-written data on monitoring the work of robots on the scene and from the analysis of the existing static norms for various other works *[5]*.

$$N_{k,r,ko_i,kd} = n_r \cdot 1/U_{k,r,ko_k,kd} = n_r / kd_c ko_k Uo_{k,r} \quad (3)$$

The very creation of the dynamic norms implies the creation of the dynamic calculations and this in turns brings a fully mathematical generation of offers by the management system of a construction company.

4. Bridge Maintenance Automation

Besides upgrading the works norm for the automation of the complex process as a whole, a reconstruction of a company's structure is needed as well so that the business system itself leads to the automation of work and integrated information systems (IIS) are the right solution for this task.

The creation of such system intended for construction (Fig. 8) yielded the preconditions for establishing a vector norm organization of the structure of a company [4, 5].

Fig 8 . IIS of a construction company with the vector structure

However, what has taken care for automation of works is the contemporary Internet digital technology which the GPS technology [6] has appeared and it converts the hand-written data into automated gathering and sending of field-data to the central data processing units within an IIS company system (Fig. 9).

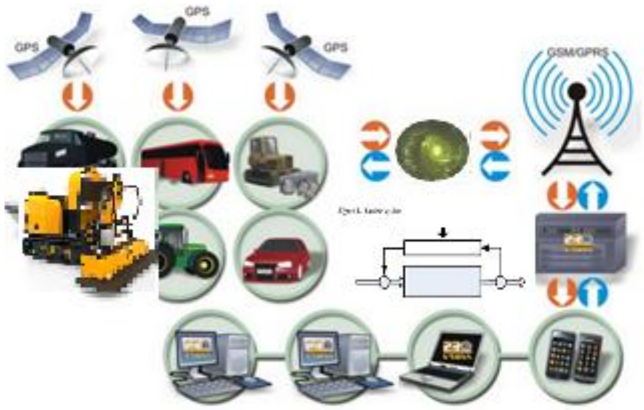


Fig 9. GPS system

5. Conclusion

Optimal investment maintenance of bridges is a result of new technologies and organizations. For this result to be simulated as well, the science of operational investigations is deployed in order to bring the respective costs to a minimum. The study of respective methods resulted in an enhanced combinatory method of planning combined with inscription equations with and without recurring and channels with and without the same dimensions (Equation 3) [7].

$$k_i = k$$

$$K = U\left[\begin{matrix} n_1 \to k_{\max} - 1 \\ n_{\max} \end{matrix} U\left[\begin{matrix} n_2 \to 1 \\ n_1 - k_i \end{matrix} U\left[\begin{matrix} n_i \to n_i + 1 \;\; n_k - 1 \\ n_1 - k_i \end{matrix} U\left[\begin{matrix} n_k \to n_1 + 1 \\ n_{\max} \end{matrix}\right]\right]\right]\right] \quad (3)$$

For the purpose of a full automation, the combinatory system regulation via the GPS technology (Fig. 10) is to be subjected to further investigation.

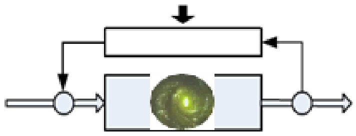


Fig. 10. System regulation

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